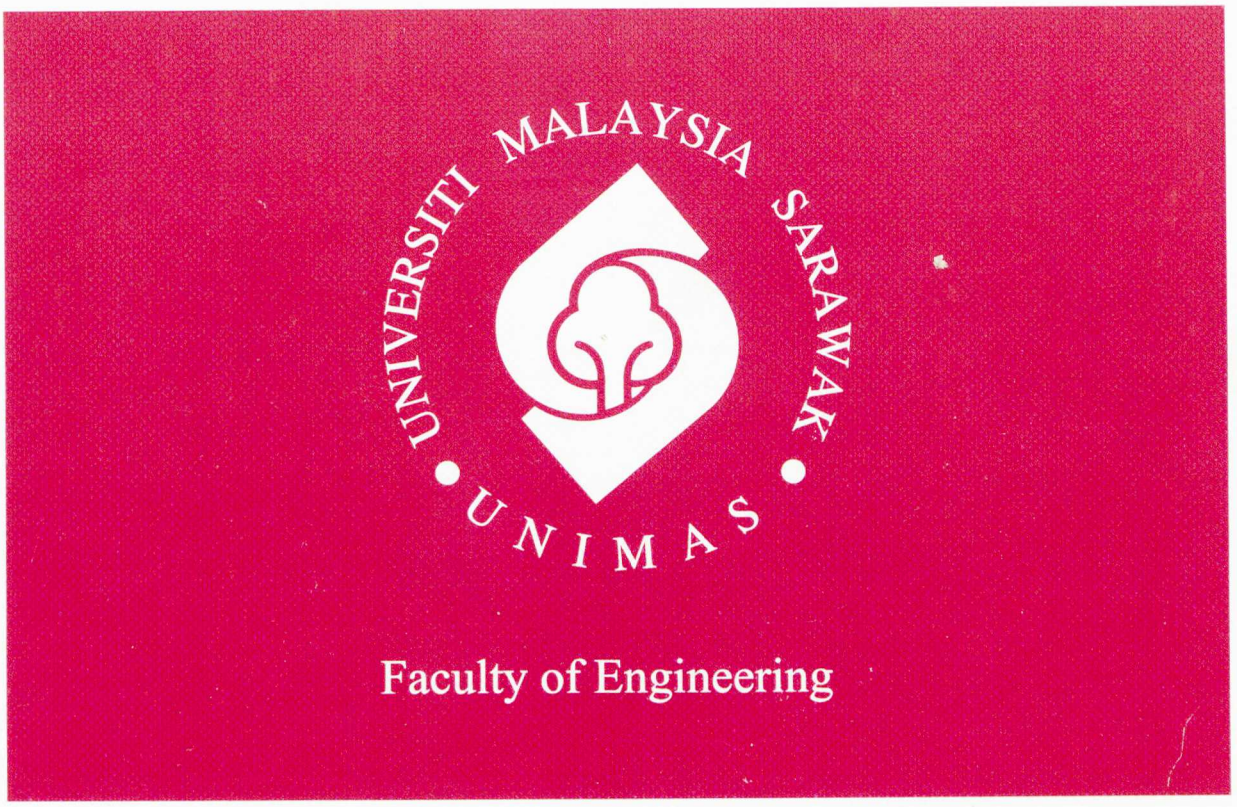


BEHAVIOUR OF COMPRESSION PROPERTIES OF SMALL CLEAR LAMINATED ACACIA HYBRID SPECIES IN SARAWAK

Ashlah Nadhirah Binti Zulkifli

Bachelor of Engineering with Honours
(Civil Engineering)
2019/2020

Behaviour of compression properties of small clear laminated *Acacia hybrid* species in Sarawak

Ashlah Nadhirah Zulkifli
Department Civil Engineering
University Malaysia Sarawak
Kota Samarahan, Sarawak, Malaysia
ashlahnadhirah34@gmail.com

Abstract— **Timber is one of the oldest and most well-known structural materials and one of the few natural resources that are renewable. *Acacia hybrid* which is produced from natural crossing between two parental timber species (*Acacia auriculiformis* and *Acacia mangium*) which it has desirable characteristics of fast growth rates and increased heart rot resistance in Sarawak. This species is used in researches for engineering purposes. Thus laminated *Acacia hybrid* of combine ages 7 with 10, 7 with 13 and 10 with 13 is used in these study to determine and compare the behavior of compression properties at different laminated. The demand of using timber as structural timber almost no existence in Malaysia. Knowledge and practices of timber in construction design still lacking among the engineers and architects. 30 pieces laminated specimens of *Acacia hybrid* being used in this testing procedure. This testing is to determine the physical and mechanical properties. These engineering properties were acquired from the rupture modulus, elasticity modulus, impact bending and compressive strength test (parallel and grain perpendicular). In the meantime, moisture content and density are assessed for physical properties. According to British Standard BS373.1957, the laminated were prepared at air-dry conditions. Thus, the result of this investigation is very useful for utilization in furniture and engineering construction industries in our country. From the findings, for 10 years old Acacia hybrid that the mean value for work done to break the specimens is 24 Joules and the mean value for compressive stress is 60.28 N/mm2. Meanwhile the basic density for 10 years old *Acacia hybrid* is 0.6780g/cm3. For the engineering utilization, the suitable age group for *Acacia hybrid* is 10 years old due to its have higher strength properties and highest density compare to 7 years and 13 years old.**

Keywords—component, formatting, style, styling, insert *(key words)*

I. INTRODUCTION

Timber has been used broadly as a building materials for a very long time. However, it does no longer means that humans have a in-depth scientific perception of the behavior of the material. Wood consequently frequently seen as a material with inadequate mechanism and documentation of its properties and behavior (Thelandersson, 2000).

The world demanded woods from Malaysia because it is categorised amongst the major manufacturer of the world's good high-quality timber. However, Malaysia is in distinction with the well-developed country due to the poor utilisation of different of the different elements in neither the engineering discipline nor constructing mechanisms in specific, (Jumaat, 2014). Despite being a central market outlet for timber products less attention receiver by Malaysia as the continually dominated through export. Besides, the customers do no longer conscious of the accessibility of trees species in Malaysia and lead the nearby market wood products being exports. Hence, the continuation of utilisation in imported timber expends ("Timber use practices in Malaysia's building industry: Single-family residential building sector," 2016).

In addition, there is almost no interest among Malaysian in using trees as a structural member. Furthermore it can proven whereby timber design course is only taught through by a few universities in Malaysia. Thus, it leads to a lack of knowledge in timber properties and design among architects and engineers. As for timber researches, only a few types of research devoted to having lookup and campaigns on the materials (Jumaat, 2014). Nevertheless, the certain research on timber products usage no longer only missing in the Malaysia building however also in different main timber product consuming sectors ("Timber use practices in Malaysia's development industry : Single-family residential building sector," 2016). As to overcome this problem, timber engineering shall be introduced in university.

Jumaat el al. (2006) lamented that the use of timber as material in building not beneficial by the construction enterprise in Malaysia. The reason been timber products is not favour material is due to the perception low quality, underrated and low fire performances, (Tan *et al.*, 2015; Ismail *et al.*, 2008).

In Malaysia, timber is confined in its utilisation solely to formwork and trusses and dealing with aggressive opposition to different materials (Jumaat, 2014). Therefore the greater challenge is to introduce timber to be used as structural materials in the construction industry. Furthermore, there are large number of alternative materials such as brick and concrete for construction.

Therefore, a study has carried out to understand the engineering properties of solid and laminated *Acacia hybrid* in a small clear sample at the air dry condition. The result from this study will be useful in the effort to utilising this species for wood-based applications in the future.

II. PREPARATION OF SPECIMEN

Samples of Acacia hybrid were taken from Daiken Sarawak Sdn Bhd, Bintulu plantation site. The trees were cut into three sections, the bottom, the middle as well as the top. For a planted tree, the tree was cut approximately 0.3048 m from the ground level. The length of each section was cut into 1.52 meter and the circumference of bole

approximately 0.74 meter. The mean diameter at breast height of 1.3m (DBH) of enumerated healthy is more than 22cm. The sample trees selected shall be taken from among trees of not less than 18cm diameter. In the case where the average diameter is less than 22 cm, sample trees of not less than 14 cm diameter shall be chosen. The sample taken must be healthy with no visible defects with the exception of knots and a clear bole of minimum 6 m from the root collar.

The log test has been sent to Samling Plywood Bintulu Sdn Bhd and put in the sawing machine before the normal air-drying process happens. Before the samples undergoing air drying, the skin of the logs must be removed. The samples will be prepared into plank sizes and stacked before sent to Sarawak Forestry Corporation (SFC) laboratory, Kuching

At this stage, to ensure the samples were protected from rain sunlight because timber is susceptible to external exposure, the samples were kept at room temperature in the laboratory. The drying procedure for the samples took a couple of months so it can accomplish the ideal moisture content. At the point when the moisture content was below 19 percent. Besides that, the samples were cut into few dimensions 20 mm x 10 mm x 60 mm for each age in order to perform mechanical tests which are compression tests. Timber with different age was glued together by used *Phenol Resorcinol Formaldehyde (PRF) 1170* to get a dimension for following the British Standard which is for compression parallel to grain test, the samples shall be laminated into 20 mm x 20 mm x 60 mm. Approximately a total of 120 timber specimens were used for the mechanical and physical test both in air-dry condition.

III. MECHANICAL PROPERTIES

Mechanical properties usually to measure the group strength of timber species. From determine the strength of timber, we can choose which timber most suitable as a structural materials. The strength properties of Acacia hybrid need to identify in order to achieve accuracy in designing structural components for a structure such as trusses or furniture. A number of mechanical tests will be conducted on different ages of Acacia hybrid at the air-dry condition. In order to determine the mechanical properties of Acacia hybrid, a compression test will be conducted according to Testing Method Manual for Small Clear, Malaysian Standard (MS) 544:2001 and British Standard 373:195.

A. Compression parallel to grain test

Generally, compressive strengths in timber have to be applied on the parallel to grain direction which was the forces are performed in parallel to grain directions when the compression load is applied at the grain angle. Parallel compression to the grain test also known as the 'Maximum crushing test. The strength, modulus of rupture (MOR) and modulus of elasticity (MOE) of Acacia hybrid was determined by using compression tests. The formula used for this test

$$\text{Compressive stress at maximum load} = \frac{F}{A}$$

Where, F: Maximum Load (N)
A: Cross- sectional area (mm^2)

The dimension of the samples for the compression parallel to grain test was 20mm x 20mm x 60mm and was applied parallel to the grain. The ends of the rectangular specimens were smoothened and normal to the axis of force to ensure the accuracy of the results. Whereas, the constant loading speed of 0.6mm/min was applied during the test.

IV. PHYSICAL PROPERTIES

Physical properties of Acacia hybrid can determine its density and moisture content. The moisture content is effect the strength and stability of timber. However, some of the timber tends to dry quickly, it is hard to accomplish the moisture contents approximately 15-19%. Therefore, in accordance with Testing Method Manual for Small Clear, Malaysian Standard (MS) 544:2001, to achieve air- dry conditions the humidity content must be below 19 percent in order while more than 19 per cent in the green condition. For density, the higher the moisture content of the material, the lower the density yet it will not influence the timber in air-dry condition and green condition.

A. Moisture content

A small clear laminated size of 20 x 20 x 20 mm was prepared for moisture content test. Moisture content is defined as the weight of dry wood and expressed as a percentage. After cutting, the specimens were weighed by using a top-loading balance. The specimens were weighed immediately if not they should be placed in a plastic bag to prevent from moisture changes. The samples also dried in electric oven with a temperature 103±2 for 24 hours or got a consistent weight. The result was recorded. The moisture content was calculated by using this equation

$$MC = \frac{m_i - m_o}{m_o} \times 100\%$$

or

$$MC = \left(\frac{m_i}{m_o} - 1\right) \times 100\%$$

Where, MC = the moisture content of wood (%)
m_i = the initial weight of test specimen (g)
m_o = the oven-dry weight of test specimen (g)

B. Density

The basic density was defined as the weight per unit volume of wood and the unit is kgm^{-2} or gcm^{-2}. The small clear laminated size was prepared for this test with a dimension of 20mm x 20mm x 20mm according to Testing Method Manual for Small Clear, Malaysian Standard (MS) 544:2001 and British Standard 373:195. Next, the samples were placed into the oven. In order to determine the green volume, the samples were calculated by using the water displacement method while the dry weight of samples was obtained by using an electronic balance. The density was measured using formula as shown:

$$\text{Density}\left(\frac{g}{cm^3}\right) = \frac{\textit{Oven Dried Weight (g)}}{\textit{Green}}$$

V. RESULT AND DISCUSSION

A. *Compression Parallel to Grain Properties*

Table I shows the compression parallel to the results of the grain test. Table I shows a mean value of 54.10 N / mm2 with the highest values of 67.30 N / mm2 for laminated Acacia hybrid aged 7 with 10 years, while the mean value of the laminated Acacia hybrid aged 7 with 13 years is 52.44 N / mm2, with the maximum value of 63.75 N / m2. Whereas for laminated Acacia hybrid 10- with 13-year-olds, the mean stress value is 57.00 N / mm2, with maximum value of 73.20 N / mm2.

From the compressive testing results it can be concluded that Acacia hybrid's average value parallel to grain of compressive strength is the highest of 57.00 N / mm2 for the ages of 10 with 13 years. The results also show that the highest strength of the 10-years old sample followed at age 13 and at age 7 is shown in the study conducted by Duju et al (2015). Meanwhile the highest mean of density reported was 10 years old when compared with 13 and 7 years. The strength of the wood, therefore increases as the density of the wood increases. (Duju, 1999).

TABLE I AVERAGE OF COMPRESSIVE STRESS

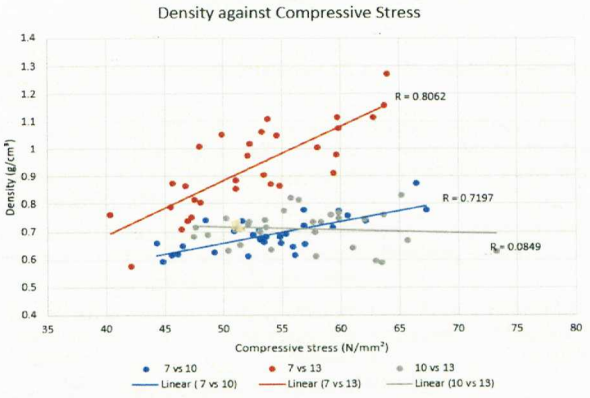
Year of Samples	Compressive stress N/mm²
7 with 10 Year	54.095
7 with 13 Year	52.437
10 with 13 Year	56.998

B. *Basic Density versus Compressive Stress*

For the Figure I where density against compressive stress parallel to grain indicates that coefficient of determine R^2 regression value for 7 with 10 Years old of Acacia hybrid is 0.518 with the correlation coefficient, R value 0.7197 . Whereas, at 7 with 13 years old the R^2 =0.6499 with R value 0.8062 and the R regression value calculated for 10 with 13 years old linear line is 0.0072 with R value 0.0849 . As compressive stress, R value for laminated 7 and 13 shows the high correlation with density. This can be concluded that the compressive stress parallel to grain of laminated Acacia hybrid at 7 with 13 years is directly proportional to basic density. However, laminated of 10 with 13 years exhibit weak correlation with density by the value of R=0.0849.

Theoretically, there should be a linear regression between compressive stress and the density of Acacia hybrid species. Although the strength of the timber reflected by the density, it should not be the actual measurement of its strength (G. Ismaili, Openg, Abdul Rahim, & Duju, 2016). This is due to the structure of the wood as it has non-homogenous properties. There will be a difference in density as the samples taken from a different portion of timber (Wood, n.d.). The results from this investigation are very important for timber design where it considers age as the crucial factor to be analysed.

Figure I Density against Compressive Stress of Acacia hybrid at Different Age



C. *Moisture Content versus Compressive Stress*

The mean content values, based on oven- dry weight and volume were 14.94 %, 13.75 % and 14.27 % for laminated 7 with 10, 7 with 13 and 10 with 13 years old. This illustrates Figure II shows that, the laminated of 7 with 10 years old of Acacia hybrid plotted that coefficient of determine R^2 is 0.0402 with the correlation coefficient, R value 0.2005. Besides, for 7 with 13 years old Acacia hybrid shows that R^2=0.0719 with R value 0.2681 and the regression value can be observed on 10 with 13 years old Acacia hybrid is 0.0133, with R value 0.1153 . It indicates that, at laminated 10 and 13 years old, the moisture content in the wood cells almost dried up as the compression resistance of Acacia hybrid increases.

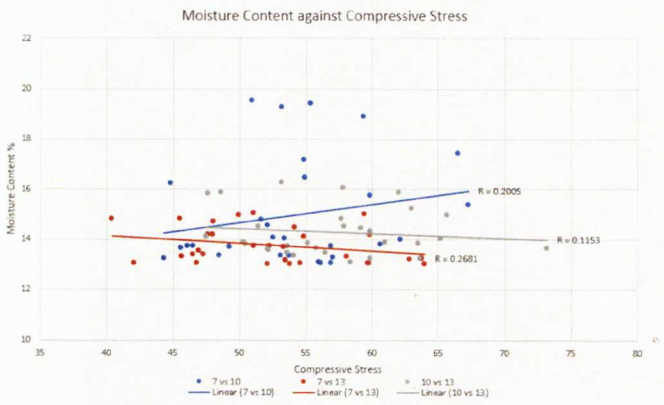
The moisture content shows nearly no correlation with compressive stress for Acacia hybrid species of Sarawak. This value show that the moisture content of acacia very weak relationship to the compressive stress of the species when age is increasing.

It can be concluded when the age is increased, the moisture content inside the wood cell become decreases and the strength properties increases. (LJ.Babic,2012) Therefore, the strength properties of timber increase when the density of timber increases. (Duju, 1999).

Timber divided into two general layers, sapwood and heartwood. The sapwood is the outer layer that consists of active and inactive cells. The function is to supply sap and food storage to the other parts of the tress. Conversely, the heartwood made up of mostly inactive cells and did not function like the sapwood (Gehri, 2010a).

As the age of tree increases, the volume of sapwood decreases while the volume of heartwood increases. Thus, this can be related to the strength of the wood even it does not shows a significant influence. In a higher age of trees, the lower the volume of the sapwood and higher in the heartwood. This proved by the graph, the moisture content of laminated Acacia hybrid is the highest at 10 with 13-years old compared to 7 with 10 and 7 with 13-years old with the increase in the compressive stress. The internal slipping of one part of timber along the grain dropped down with a rise in the moisture content (Gehri, 2010a) .

Figure II Moisture Content against Compressive Stress of Acacia hybrid at Different Age



ACKNOWLEDGMENT

The author would like to gratefully acknowledge everyone involve in this project.

REFERENCES

[1] Duju, A. (1999). Strength Properties of Acacia mangium Grown in Sarawak.

[2] Bin Ismaili, G. (2015). Engineering Properties of Fast Growing Indigenous Timber in Sarawak Compare to Acacia Mangium: Aras. International Journal of Innovative Science and Modern Engineering (IJISME), (2), 2319–6386.

[3] Alik Duju (1999), Strength Properties of Acacia mangium Grown in Sarawak. TRTTC/STA, Forest Products Seminar, 12-14 October 1999, Kuching, Sarawak, Malaysia. 160pp.

[4] Jumaat, M. Z., Rahim, a H. a, Othman, J., & Razali, F. M. (2006). Timber engineering research and education in Malaysia, 3, 2494–2497. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.084870022980&partnerID=40&md5=bec7292af4d5c7517134c2dda5b9a249

[5] British Standard (1957). Methods of Testing Small Clear Specimen of Timber. British Standard Institution. BS 373: 1957. 31pp.

Name : ASHLAH NADHIRAH BINTI ZULKIFLI

Email : ashlah_nadhirah@yahoo.com

Phone number : 012-9465739

UNIVERSITI MALAYSIA SARAWAK

Grade:

Please tick (√)	
Final Year Project Report	√
Masters	
PhD	

DECLARATION OF ORIGINAL WORK

This declaration is made on the .....5.....day of.....AUGUST.....2020.

Student's Declaration:

I ASHLAH NADHIRAH BINTI ZULKIFLI 50410 from FACULTY OF ENGINEERING declare that the work entitled **BEHAVIOUR OF COMPRESSION PROPERTIES OF SMALL CLEAR LAMINATED ACACIA HYBRID SPECIES IN SARAWAK** is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

25 AUGUST 2020
Date submitted

ASHLAH NADHIRAH BINTI ZULKIFL (50410)
Name of the student (Matric No.)

Supervisor's Declaration:

I DR GADDAFI BIN ISMAILI (SUPERVISOR'S NAME) hereby certifies that the work entitled BEHAVIOUR OF COMPRESSION PROPERTIES OF SMALL CLEAR LAMINATED ACACIA HYBRID SPECIES IN SARAWAK (TITLE) was prepared by the above named student, and was submitted to the "FACULTY" as a * partial/full fulfillment for the conferment of DEGREE OF BACHELOR OF ENGINEERING WITH HONOURS(CIVIL ENGINEERING)(PLEASE INDICATE THE DEGREE), and the aforementioned work, to the best of my knowledge, is the said student's work.

Received for examination by: DR GADDAFI BIN ISMAILLI Date: 5 AUGUST 2020
(Name of the supervisor)

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

Please tick (√)

Final Year Project Report	√
Masters	
PhD	

DECLARATION OF ORIGINAL WORK

This declaration is made on the .....5.....day of.....AUGUST.....2020.

Student's Declaration:

I ASHLAH NADHIRAH BINTI ZULKIFLI 50410 from FACULTY OF ENGINEERING declare that the work entitled **BEHAVIOUR OF COMPRESSION PROPERTIES OF SMALL CLEAR LAMINATED ACACIA HYBRID SPECIES IN SARAWAK** is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

15 AUGUST 2020
Date submitted

ASHLAH NADHIRAH BINTI ZULKIFL (50410)
Name of the student (Matric No.)

Supervisor's Declaration:

I DR GADDAFI BIN ISMAILI (SUPERVISOR'S NAME) hereby certifies that the work entitled BEHAVIOUR OF COMPRESSION PROPERTIES OF SMALL CLEAR LAMINATED ACACIA HYBRID SPECIES IN SARAWAK (TITLE) was prepared by the above named student, and was submitted to the "FACULTY" as a * partial/full fulfillment for the conferment of DEGREE OF BACHELOR OF ENGINEERING WITH HONOURS(CIVIL ENGINEERING)(PLEASE INDICATE THE DEGREE), and the aforementioned work, to the best of my knowledge, is the said student's work.

Received for examination by: DR GADDAFI BIN ISMAILLI Date: 5 AUGUST 2020
(Name of the supervisor)

I declare that Project/Thesis is classified as (Please tick (√)):

☐ **CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972) *
☐ **RESTRICTED** (Contains restricted information as specified by the organisation where research was done) *
☑ **OPEN ACCESS**

Validation of Project/Thesis

I therefore duly affirmed with free consent and willingness declare that this said Project/Thesis shall be placed officially in the Centre for Academic Information Services with the abiding interest and rights as follows:

- This Project/Thesis is the sole legal property of Universiti Malaysia Sarawak (UNIMAS).
- The Centre for Academic Information Services has the lawful right to make copies for the purpose of academic and research only and not for other purpose.
- The Centre for Academic Information Services has the lawful right to digitalise the content for the Local Content Database.
- The Centre for Academic Information Services has the lawful right to make copies of the Project/Thesis for academic exchange between Higher Learning Institute.
- No dispute or any claim shall arise from the student itself neither third party on this Project/Thesis once it becomes the sole property of UNIMAS.
- This Project/Thesis or any material, data and information related to it shall not be distributed, published or disclosed to any party by the student except with UNIMAS permission.

Student signature _____ (Date)

Supervisor signature: _____ (Date)

Current Address:
B11 LORONG PUSARA, KAMPUNG ATAS TOL, 21070 KUALA TERENGGANU

Notes: * If the Project/Thesis is **CONFIDENTIAL** or **RESTRICTED**, please attach together as annexure a letter from the organisation with the period and reasons of confidentiality and restriction.

[The instrument is duly prepared by The Centre for Academic Information Services]

BEHAVIOUR OF COMPRESSION PROPERTIES OF SMALL CLEAR LAMINATED ACACIA HYBRID SPECIES IN SARAWAK

ASHLAH NADHIRAH BINTI ZULKIFLI

A dissertation submitted in partial fulfillment

of the requirement for the degree of

Bachelor of Engineering with Honours

(Civil Engineering)

Faculty of Engineering

University Malaysia Sarawak

2019/2020

To my beloved family and friends

ACKNOWLEDGMENT

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I am Ashlah Nadhirah binti Zulkifli would like to extend my heartfelt gratitude and appreciation to all those who provided me the possibility to complete these Final Year Project report and bring this research to the end. Besides, I want to offer this endeavor to our God Almighty, Allah S.W.T for His wisdom bestowed upon me, the strength, the peace of mind and good health in order to finish this report.

I also would like to thank my supervisor of Final Year Project, Dr. Gaddafi bin Ismaili whose expertise, understanding, generous guidance and his support made it possible for me to work on this study that was great interest to me. It was a pleasure to have he as my supervisor. Not to be forgotten, I would like to express my gratitude towards my family especially my father, Mr. Zulkifli bin Awang and my mother, Mrs. Wan Mazni binti Wan Besar and all my siblings for the encouragement which is always supported me to complete this research.

My gratitude goes to Mr. Nungah Liang from Sarawak Forestry Corporation (SFC) Kuching for his full cooperation and assistance in preparing the testing samples, machinery and equipment to conduct this project. Last but not least, my thanks and appreciations also goes to my fellow friends and all the people who willingly to help me out finishing this report with their abilities.

Thank you.

ABSTRACT

Timber is one of the oldest and most well-known structural materials and one of the few natural resources that are renewable. *Acacia hybrid* which is produced from natural crossing between two parental timber species (*Acacia auriculiformis* and *Acacia mangium*) which it has desirable characteristics of fast growth rates and increased heart rot resistance in Sarawak. This species is used in researches for engineering purposes. Thus laminated *Acacia hybrid* of combine ages 7 with 10, 7 with 13 and 10 with 13 is used in these study to determine and compare the behavior of compression properties at different laminated. The demand of using timber as structural timber almost no existence in Malaysia. Knowledge and practices of timber in construction design still lacking among the engineers and architects. 30 pieces laminated specimens of *Acacia hybrid* being used in this testing procedure. This testing is to determine the physical and mechanical properties. These engineering properties were acquired from the rupture modulus, elasticity modulus, impact bending and compressive strength test (parallel and grain perpendicular). In the meantime, moisture content and density are assessed for physical properties. According to British Standard BS373.1957, the laminated were prepared at air-dry conditions. Thus, the result of this investigation is very useful for utilization in furniture and engineering construction industries in our country. From the findings, for 10 years old Acacia hybrid that the mean value for work done to break the specimens is 24 Joules and the mean value for compressive stress is 60.28 N/mm2. Meanwhile the basic density for 10 years old *Acacia hybrid* is 0.6780g/cm3. For the engineering utilization, the suitable age group for *Acacia hybrid* is 10 years old due to its have higher strength properties and highest density compare to 7 years and 13 years old.

ABSTRAK

Kayu adalah salah satu bahan struktur tertua dan paling terkenal dan salah satu daripada sumber semula jadi yang sedikit yang boleh diperbaharui. Acacia hibrid yang dihasilkan dari persimpangan semula jadi antara dua spesies kayu ibu bapa (Acacia *auriculiformis* dan Acacia *mangium*) yang mempunyai ciri-ciri kadar pertumbuhan yang pantas dan peningkatan rintangan jantung di Sarawak. Spesies ini digunakan dalam penyelidikan untuk tujuan kejuruteraan. Oleh itu, lapisan Acacia hybrid menggabungkan umur 7 dengan 10, 7 dengan 13 dan 10 dengan 13 digunakan dalam kajian ini untuk menentukan dan membandingkan sifat sifat mampatan pada berlapis yang berlainan. Permintaan menggunakan kayu sebagai kayu struktur hampir tidak wujud di Malaysia. Pengetahuan dan amalan kayu dalam reka bentuk pembinaan masih kurang di kalangan jurutera dan arkitek. 30 keping spesimen berlapis daripada Acacia hibrid yang digunakan dalam prosedur ujian ini. Ujian ini adalah untuk menentukan sifat fizikal dan mekanik. Ciri-ciri kejuruteraan ini diperolehi daripada modulus pecah, modulus keanjalan, kesan lenturan dan ujian kekuatan mampatan (selari dan butiran tegak lurus). Sementara itu, kandungan dan kepadatan lembapan dinilai untuk sifat fizikal. Menurut British Standard BS373.1957, laminasi disediakan di keadaan udara kering. Oleh itu, hasil siasatan ini sangat berguna untuk kegunaan industri perabot dan pembinaan kejuruteraan di negara kita. Daripada penemuan ini, selama 10 tahun Acacia hibrida, nilai min bagi kerja yang dilakukan untuk memecahkan spesimen adalah 24 Joules dan nilai min untuk tegasan mampatan ialah 60.28 N / mm2. Sementara itu, kepadatan asas untuk Acacia hybrid berusia 10 tahun ialah 0.6780g / cm3. Untuk kegunaan kejuruteraan, kumpulan usia yang sesuai untuk Acacia hybrid berusia 10 tahun kerana mempunyai sifat kekuatan yang lebih tinggi dan ketumpatan tertinggi berbanding dengan 7 tahun dan 13 tahun

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 General

The last two decades, timber has been an essential element in the building. It has a high demand for green building practice, and it has shown more concern toward environmental benefits for this alternative method in the construction industry. Timber is the woodland items utilised for development around the globe. Timber is wood at any phase between its felling and availability for its uses as an auxiliary material for development. The utilisation of timber began back at antiquated time around 500 to 100 B.C. During the time, timber ordinarily utilised in rooftop development by the antiquated Roman and Egyptian civilisation. As time passes, its utilisation extended to timber confining. Then, the utilisation of timber confining develops crosswise over Asia, Africa, and the unfamiliar Americas.

Timber has constantly favored as development materials as a result of its plenitude, high mechanical properties and simple to shape. Timber is a non-poisonous item as it matured normally. A wooden structure sets aside a little effort to develop. The development of the structure likewise not expose to climate conditions. Additionally, it can set aside cash for the development as they permit careful arranging and fast gathering. Timber as material act more typically than different materials in flames. It contains water and a poor warmth conductor.

Figure 1.1 shows the proof of present-day tallest timber building, which is a nine-story Murray Grove Tower in London, United Kingdom (Thistleton, 2007). It was accepted to be built in the initial scarcely any years in the 21st century. It is being built utilising overlaid timber divider and floor boards. Figure 1.2 shows the proof of the most seasoned existent of timber building, to be specific The Horyu-ji Buddhist Temple (Shoichi, 2000). This structure is situated in Japan and the worked around 1300 years back, and it was conceivably prior. The structure was a five-story pagoda. Dried timber that remaining parts dry normally does not rot.

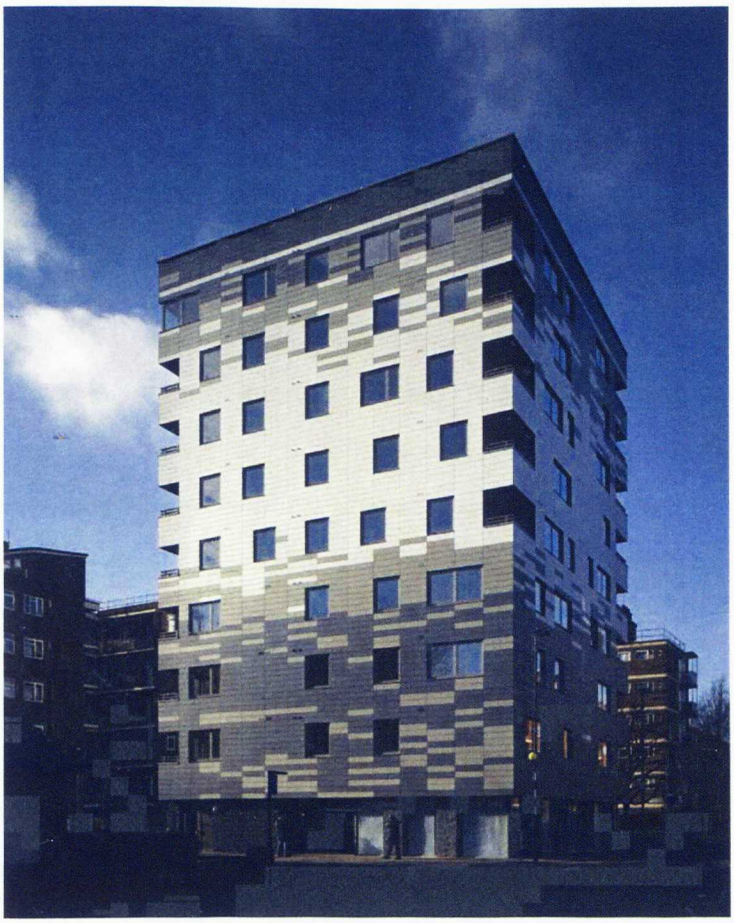


Figure 1.1 The tallest timber construction, Murray Grove Tower (Thistleton, 2007)

Figure 1.2 The oldest timber construction, The Horyuji Buddist Temple (Inoue Shoichi, 2000)

Malaysia is one of the world's driving makers of fine wood on the planet who are in desperate need of overall interest (Jumaat, Rahim, Othman, and Razali, 2006). However, the usage of timber as a construction building material in Malaysia is relatively minimal though it has rich resources. Its utilisation just restricted to formwork and supports. Timber in Malaysia confronting the furious challenge with different materials in development.

Sarawak is the biggest state in Malaysia and has the world's most established rainforest with the size of Austria. As mentioned by Haji Bojet and Jimbat (1996), Sarawak has over 68% or 8.4 million of hectares of its all-out land region of 12.3 million hectares are under common backwoods spread. Twenty-seven percent or 3.7 million hectares are under optional woodland, and about 5% or exactly 600 000 hectares are under development or has been utilised for improvement. Sarawak is honoured with a plenitude of natural assets. Sarawak woods contains most significant assets and resources, delivering timber and many backwoods items. Sarawak's backwoods additionally as one of the biggest exporter of tropical hardwood timber.

1.2 Problem Statement

Timber has been used broadly as a building materials for a very long time. However, it does no longer means that humans have a in-depth scientific perception of the behavior of the material. Wood consequently frequently seen as a material with inadequate mechanism and documentation of its properties and behavior (Thelandersson, 2000).

The world demanded woods from Malaysia because it is categorised amongst the major manufacturer of the world's good high-quality timber. However, Malaysia is in distinction with the well-developed country due to the poor utilisation of different of the different elements in neither the engineering discipline nor constructing mechanisms in specific, (Jumaat, 2014). Despite being a central market outlet for timber products less attention receiver by Malaysia as the continually dominated through export. Besides, the customers do no longer conscious of the accessibility of trees species in Malaysia and lead the nearby market wood products being exports. Hence, the continuation of utilisation in imported timber expends ("Timber use practices in Malaysia's building industry: Single-family residential building sector," 2016).

In addition, there is almost no interest among Malaysian in using trees as a structural member. Furthermore it can proven whereby timber design course is only taught through by a few universities in Malaysia. Thus, it leads to a lack of knowledge in timber properties and design among architects and engineers. As for timber researches, only a few types of research devoted to having lookup and campaigns on the materials (Jumaat, 2014). Nevertheless, the certain research on timber products usage no longer only missing in the Malaysia building however also in different main timber product consuming sectors ("Timber use practices in Malaysia's development industry : Single-family residential building sector," 2016). As to overcome this problem, timber engineering shall be introduced in university.

Jumaat el al. (2006) lamented that the use of timber as material in building not beneficial by the construction enterprise in Malaysia. The reason been timber products is not favour material is due to the perception low quality, underrated and low fire performances, (Tan *et al.*, 2015; Ismail *et al.*, 2008).

In Malaysia, timber is confined in its utilisation solely to formwork and trusses and dealing with aggressive opposition to different materials (Jumaat, 2014). Therefore the greater challenge is to introduce timber to be used as structural materials in the construction industry. Furthermore, there are large number of alternative materials such as brick and concrete for construction.

Therefore, a study has carried out to understand the engineering properties of solid and laminated *Acacia hybrid* in a small clear sample at the air dry condition. The result from this study will be useful in the effort to utilising this species for wood-based applications in the future.

1.3 Aim and Objective of the Study

This investigation aims to study the engineering properties of *Acacia hybrid* at different age by using a small clear method as stated in Testing Method Manual for Small Clear, Malaysian Standard (MS) 544:2001 and of British Standard BS373:1957. The following objectives have been identified as follows:

1. To determine the engineering properties of laminated *Acacia hybrid.*
2. To compare and evaluate the behaviour of compression properties of laminated *Acacia hybrid*
3. To identify the best result compression properties of laminated *Acacia hybrid* from different age combination.